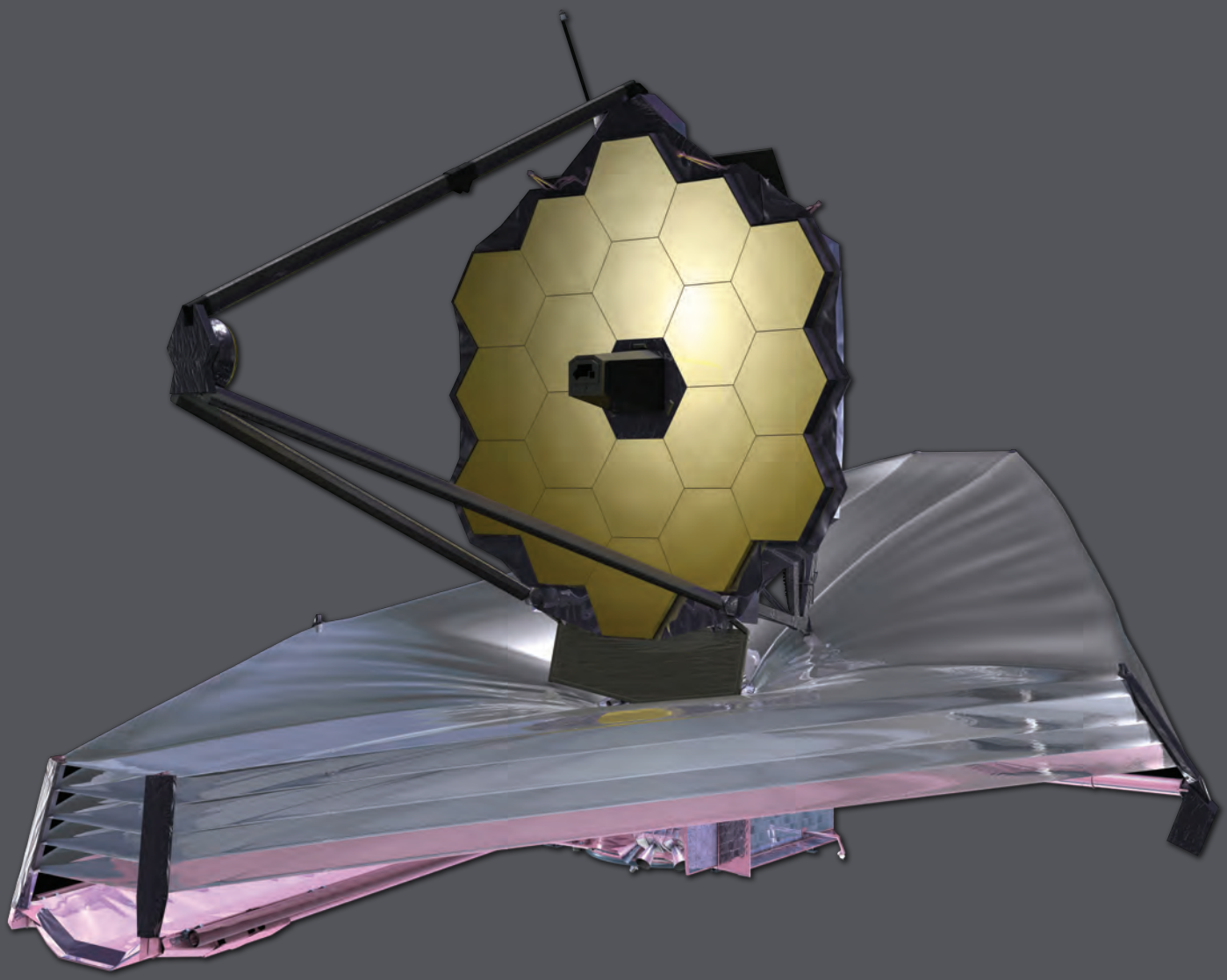
CASE STUDY

Keeping the James Webb Space Telescope on Track



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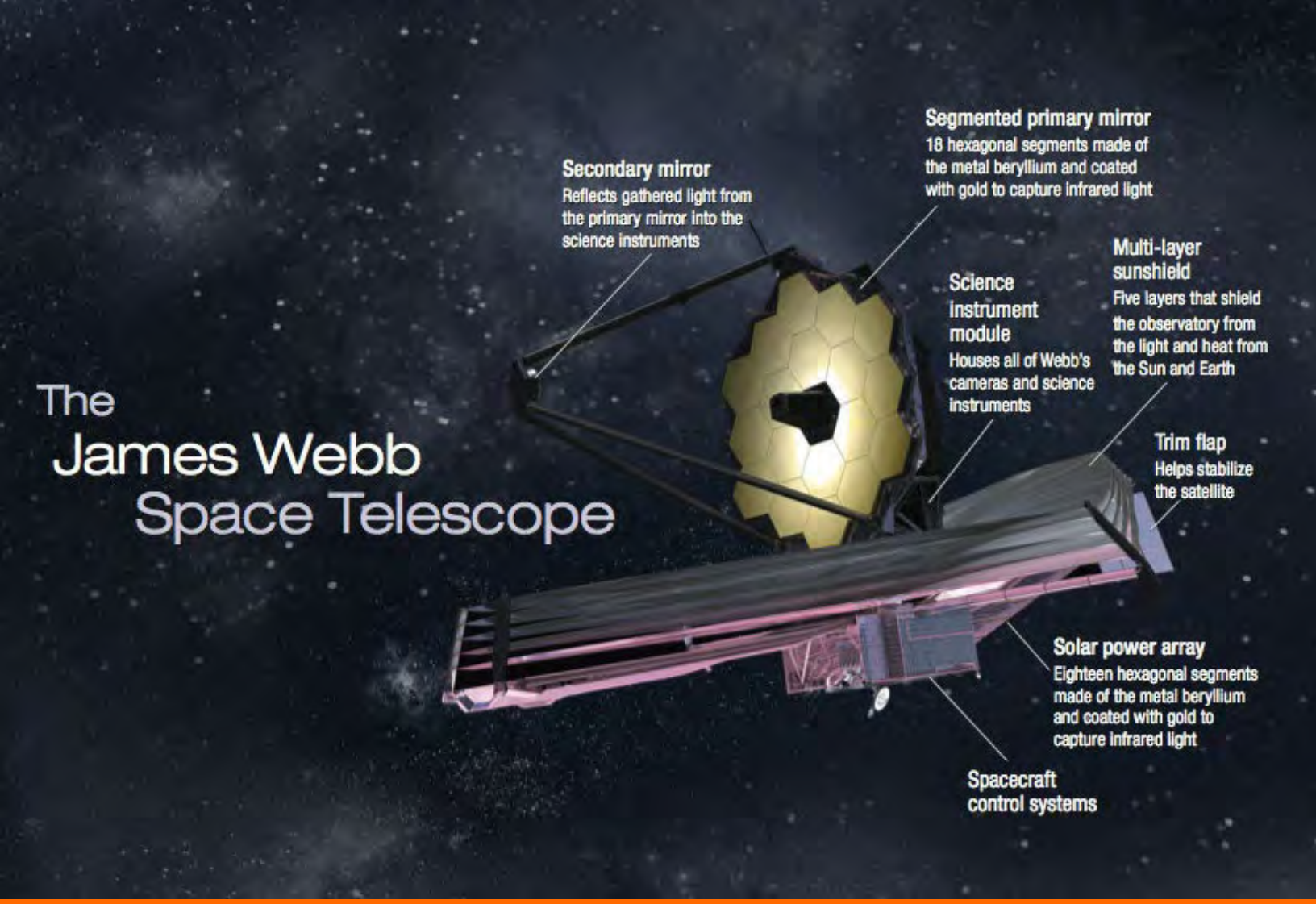


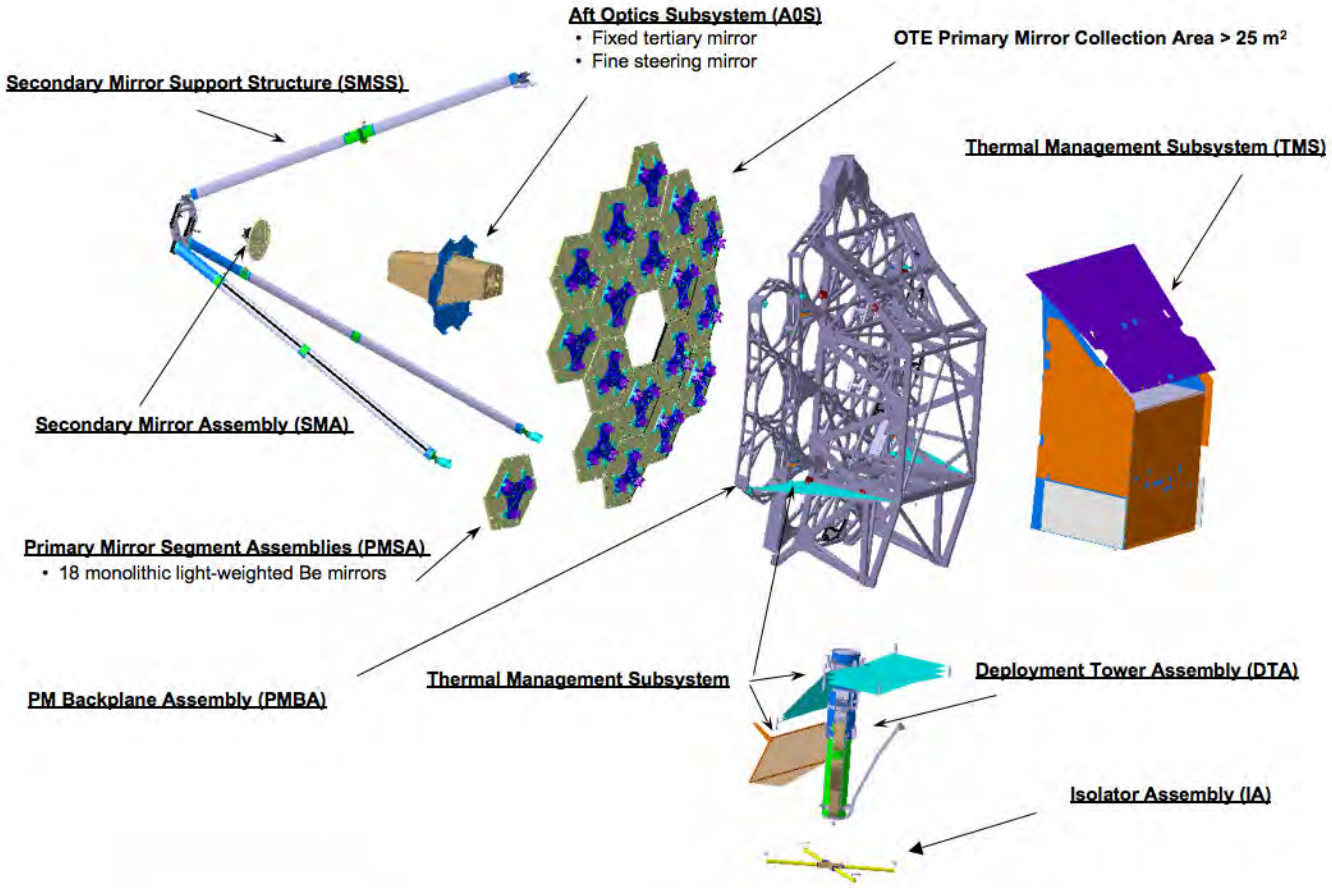
In October 2018, NASA, the Canadian Space Agency (CSA), and the European Space Agency are set to launch the James Webb Space Telescope. Billed as the successor to the Hubble Space Telescope, Webb will be the most complex and powerful telescope ever built. It will be able to see through dust clouds which absorb visible light, and it will also help scientists to see further back in time. Orbiting a million miles from the Earth and using a viewing area that is seven times larger than Hubble, Webb will capture the infrared signals from the first stars and galaxies over 13.5 billion years ago.

Crucial to Webb's success is a Fine Guidance Sensor (FGS), a means of positioning the telescope that will orient it for target acquisition and provide image stabilization during scientific observations. COM DEV International Ltd. was contracted in 2001 to begin development of the hardware and software for Webb's FGS. COM DEV had experience contributing to over 950 satellite projects, but this was still an enormous task, and a failure to deliver would set back the entire Webb project.

Late-stage space simulation tests uncover a crippling problem

Unfortunately, late-stage tests in 2013 uncovered serious problems with the FGS' control system. When the hardware was tested in space-simulating conditions (these were as cold as -240°C), some scenarios caused the system to lock up and behave inconsistently. It was clear that there was an issue with the FGS, but the problematic behaviour proved very difficult to reproduce, which meant that diagnosing the problem would not be at all straightforward.

The problem was critical and it threatened to delay the entire global project. The software inconsistencies had to be quickly diagnosed and fixed, written into new Field Programmable Gate Array (FPGA) integrated circuits, and then re-installed into the FGS system. System verification testing would also have to be redone, costing over $1M and slowing down the parallel development of other systems and instruments. Furthermore, if replacing the FGPAs caused any damage to the host circuit boards, it would create delays which would be disastrous for the whole Webb program. COM DEV had to get the re-coding right on their very first attempt.



A rapid diagnosis, then the challenge of convincing NASA

At the end of December 2013, COM DEV's Chief Engineer Brian MacKay engaged Peter Cottreau – VP of Electronics at Design 1st – to review and recommend fixes for the existing code and architecture of the FGS. Peter had successfully assisted COM DEV on a previous satellite project. He immediately set to work, and quickly discovered the problem. At crossover points between unrelated 'time domains', the FGS code was unable to handle exception conditions that required special processing. These exception conditions were very difficult to reproduce, which explained why the problem had been identified so late in testing. And the code's inability to handle the conditions meant that there were a number of scenarios which would simply cause the FGS to lock up.

Peter proposed changes to the 3,000 lines of code, and he and the COM DEV team then had to convince NASA and the world's other preeminent space authorities that the changes would completely resolve all issues with the software. After the initial green light was given to proceed, Peter re-wrote the FPGA code and developed a testing framework to verify that his changes were effective. Progress was tracked through frequent meetings with staff from COM DEV, CSA, and NASA. These meetings were not for the faint-hearted, as the risks and costs involved in the work could hardly have been higher.

"Once we made the decision to update the FPGA code, a long sequence of events had to be executed properly and without failures," explains COM DEV's Chief Engineer Brian MacKay. "Peter was instrumental in finding and implementing the necessary fixes for the FGS."

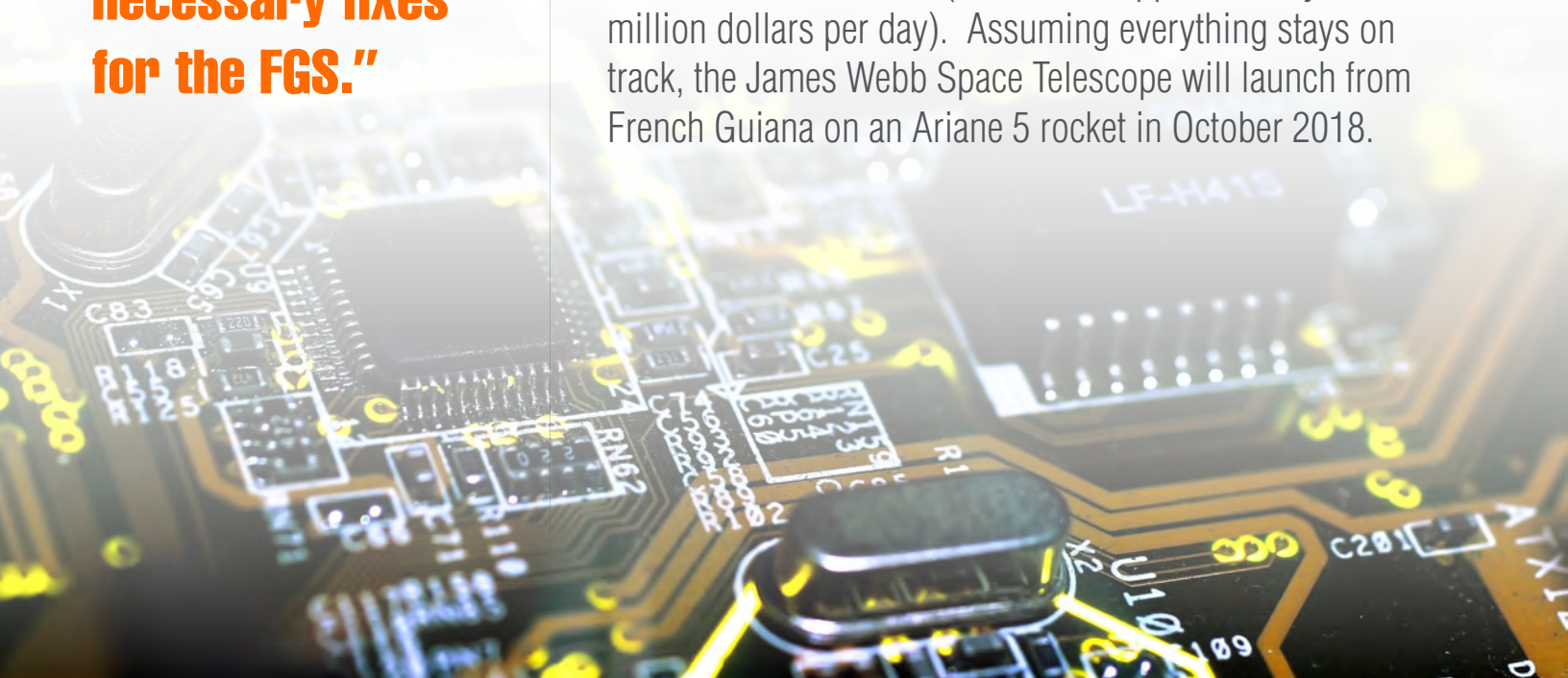
Getting it right the first time

Peter did not disappoint – he and COM DEV completed the software updates on schedule by the end of August 2014. The software was written to new FPGAs, which were then successfully installed on the FGS without damaging the host circuit boards.

In February 2015, the FGS was one of the first instruments to be installed in Webb's Integrated Science Instrument Module (ISIM) at NASA's Goddard Space Flight Center. NASA describes the ISIM as the heart of Webb; it houses the main instruments used to detect light from distant stars and galaxies. And with the FGS installed, the ISIM passed electronic check-out tests with flying colors. The ISIM was tested for a second time in August: it was vigorously shaken and bombarded with intense acoustical waves to simulate the harsh conditions of a launch. And once again, it sailed through the tests with no issues.

The James Webb Space Telescope today

In mid-November 2015, the final round of testing started – 4 months in a -240°C vacuum in Goddard's Space Environment Simulator (at a cost of approximately one million dollars per day). Assuming everything stays on track, the James Webb Space Telescope will launch from French Guiana on an Ariane 5 rocket in October 2018.



Peter Cottreau, VP of Electronics

About Design 1st and Peter Cottreau

Design 1st is one of the largest, most experienced product design firms in Canada, with over 500 projects, 18 years, and 130 patents under its belt. Their industrial design, engineering, electronics, software, and manufacturing setup experts work as a cohesive team to transform ideas into winning products.

Peter Cottreau is the Vice President of Electronics at Design 1st and is a specialist in FPGA development, holding a number of patents. Prior to joining Design 1st, Peter was the founder and CEO of Ashton Electronic Systems and held senior technical and management roles at Cisco, Picarro, BlueLeaf Networks, StratumOne, Plaintree Systems, and Mitel

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